NAVAL HEALTH RESEARCH CENTER

GET SMARTS!

(SPORTS Medicine Research Team System):

A COMPUTERIZED OUTPATIENT DATA COLLECTION SYSTEM FOR EPIDEMIOLOGICAL RESEARCH

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Get SMARTS! (Sports Medicine Research Team System): A computerized outpatient data collection system for epidemiologic research

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ABSTRACT

Objectives. A computerized outpatient data collection system was designed to support musculoskeletal injury epidemiologic research. This report describes features of the Sports Medicine Research Team System (SMARTS) and reviews results of a SMARTS-supported prospective study of male Marine Corps recruits undergoing basic training.

Methods. The user-friendly, menu-driven SMARTS software program was developed to track outpatient encounter data in military populations. SMARTS has been installed in medical clinics on 6 military bases and contains 110,793 records on 53,638 patients as of November 1995.

Results. Of 1241 male Marine Corps recruits from January to August 1993, 15% attrited, 85% graduated, and 40% of graduates were diagnosed with a musculoskeletal injury. Lower extremity injuries were most common (73%), followed by back and neck (9%) and upper extremity (5%) injuries. Peaks of injury presentation occurred the second to third week and tenth week of training.

Conclusions. SMARTS has applicability in clinical and research settings. Successfully exported into outpatient clinics, SMARTS supports prospective epidemiologic research. Software systems such as SMARTS can increase data collection efficiency for determination of morbidity rates, risk correlates, and fiscal and functional impacts of injuries and diseases.

[SMARTS]

INTRODUCTION

Ambulatory health care-based epidemiologic research is increasingly in demand as a means to determine disease rates and risks, perform cost-benefit analyses, measure treatment efficacy, and design and evaluate preventive interventions. This research can be extremely labor intensive, particularly when data are extracted from written health care records or large samples are required. The U.S. Navy Medical Department has recently assembled a multi-disciplinary team, the Sports Medicine Research Team (SMART) for the purpose of defining the rates and spectrum of outpatient musculoskeletal injuries in military populations, identifying risk profiles for injury, and designing effective interventions. The volume of patient encounters at military medical clinics can be extremely high. For example, the medical department at the U.S. Navy Recruit Training facility in Great Lakes, Illinois experiences 20,000 outpatient visits monthly. Thus, an automated data collection system was determined to be an essential requirement for military epidemiologic research.

To support this research effort, a user-friendly menu-driven program SMART System (SMARTS) containing personal demographics, medical complaints, diagnoses, disposition, and other relevant fields was developed for the personal computer. SMARTS was designed to have the flexibility to function as either

[SMARTS]

a clinical practice database with real-time data entry and limited data preprocessing or a research database, with more detailed data preprocessing and verification.[1,2,3] It records demographics, clinic visit information and ICD-9-based diagnoses. Additional features include automated data backup and uploading and easy system maintenance. To enhance compliance and accuracy, data entry sheets serve as the hard-copy medical record. The system also was programmed to perform administrative functions and generate reports. It further serves as a real-time surveillance tool to identify changes in patterns of disease distribution. This paper describes SMARTS, reviews results of a study using this system, and discusses applicability of this type of system in clinical and research settings.

[SMARTS]

METHODS

SMARTS is a user-friendly data collection system written in Microsoft FoxPro version 2.5 for DOS and requires at least a 386 microprocessor. On-line help was programmed into SMARTS and technical support is provided by SMARTS programming staff. Variables recorded in SMARTS cover a wide range of demographic, training status, encounter, and clinical data (Table 1).

The SMARTS program is divided into two main modules, designated System and SMART. Each is further divided into submodules. Six System submodules appear onscreen: Help, System Maintenance, Calculator, Calendar/Diary, Clear, and Quit (Figure 1). The Help submodule assists users by providing explanations of commands used in the program. System Maintenance allows production of diskette back-up copies of data and export of data via modem. SMARTS uses the communication software package ProComm Plus and Aspect script language version 2.01 to transfer data. The Calculator and the Calendar/Diary submodules are unaltered from FoxPro and remain in SMARTS for personal use as needed. The Clear submodule clears the screen, and the Quit module executes exit from SMARTS.

The SMART module has five submodules: Daily Update Tasks, Patient Menu, Diagnosis, Reports, and Maintenance (Figure 2). Daily Update Tasks allows the user to maintain current patient

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information by updating a previously unknown diagnosis to a working or final diagnosis by modifying data entry fields. The Patient Menu options include checking-in and checking-out of patients as well as express check-in, which allows the user to save time by entering only the patient's social security number (SSN) with the remaining information added at a more convenient time. Diagnosis, the third submodule, is used to reference ICD-9 codes.[3] An expanded ICD-9 code, which created more specific injury designations by building onto existing ICD-9 code, was devised for musculoskeletal/orthopedic diagnoses. For diagnoses of musculoskeletal disorders, SMARTS modified ICD-9 lists can be prompted by anatomic location.

The Reports submodule provides routines to perform inquiries, check data, and produce reports. Reports are available on morbidity for an individual patient or for groups of patients across encounter dates and diagnoses (Figure 3). This submodule also provides a daily log and a provider log which tally the number of patients seen daily. The Maintenance submodule allows each clinic to manage listings of its health care providers and class schedule.

RESULTS

Implementation

From July 1992 to November, SMARTS was installed in 6 military training bases and a total of 110,793 records on 53,638 patients were collected. The 2 initial sites, which served as pilot sites for software development, were the Marine Corps Recruit Depot (MCRD), San Diego, California and the Basic Underwater Demolition/SEAL School (BUD/S), Coronado, California. Modifications which resulted from this piloting included: consolidation of registration with check-in and check-out on a single screen, express patient check-in for repeat visits, a screen of the 20 most common diagnoses, linking of records (e.g., linking repeat visits to the initial visit), and incremental back-up.

Following pilot work, the system was exported to 4 additional sites: the Marine Corps Officer Candidate School (OCS), Quantico, Virginia; The Basic School (TBS), Quantico; the Naval Training Center (NTC), Orlando, Florida; and Lackland Air Force Base, San Antonio, Texas. The application was customized for each site, including programming for administrative reports and requirements (e.g., morbidity reports and consultation logs). In 5 of the clinics, all medical events are captured; at MCRD, only sports medicine visits are entered.

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Epidemiology of Musculoskeletal Injuries in Marine Recruits, MCRD, San Diego

Results from a study on the epidemiology of overuse injury in male recruits in basic training at MCRD, San Diego, illustrates the applicability of SMARTS. From 12 January 1993 to 15 August 1993, 1241 male Marine recruits were enrolled and prospectively followed for 12 weeks of basic training. Enrollment consisted of completion of an investigator administered questionnaire after informed consent was obtained. The questionnaire included demographics, use of tobacco and alcohol, prior medical history, previous injuries, and exercise history. The cohort was followed for outcomes including attrition, graduation, and medical visits to the Sports Medicine Clinic, which were captured in SMARTS. Incidence rates by week of training and injury rates were calculated using successful graduates as a denominator.

Of 1,241 subjects, 184 (15%) attrited and 1,057 graduated; 424 (40.0%) of the graduates were diagnosed with a musculoskeletal injury at some time during their training. The majority of injuries occurred in the lower extremity (73%), followed by the back and neck (9%), and upper extremity (5%). The most common injury pathologies were overuse in nature, including tendinitis, sprains, strains, and stress fractures (Table 2). Common specific injury diagnoses were ankle sprains,

[SMARTS]

blisters, and iliotibial band syndrome (Table 2). One of the fields calculated in SMARTS is the numerical training day. When injury was examined according to training week of clinical presentation, 2 peaks were identified: (1) the second and third week of training, and (2) the tenth week (Figure 4).

Lost days of training for those who graduated were calculated using the patient disposition field. For the 5 most common diagnoses, lost training days totaled 1091. Lost training days due to all musculoskeletal injuries totalled 3,113. When extrapolated to the 22,000 recruits processed annually, it can be estimated that 53,600 lost training days attributable to musculoskeletal injuries occur each year at MCRD, San Diego. Fiscal costs, calculated for the associated delays in training (i.e., daily room and board) and attrition (i.e., processing costs), totaled $16.5 million annually when extrapolated to the total recruit population at MCRD, San Diego.

DISCUSSION

SMARTS has been developed and implemented as an automated data collection system and successfully exported into 6 ambulatory care clinics to support epidemiologic research on musculoskeletal injuries in military training populations. The software was designed as a manpower multiplier to address the large number of outpatient encounters needed to perform prospective epidemiologic research.

Medical events are captured in SMARTS as outcome measures, eliminating the need for tedious medical record review. For quality control, the records can be sampled and reviewed to verify the accuracy of the assigned diagnoses. Diagnoses are classified using an expanded ICD-9 system. For the purposes of musculoskeletal research, more specific diagnoses and associated ICD-9 codes were necessary. Thus, an expanded ICD-9 system that more specifically codes musculoskeletal injuries was developed based on the widely used and internationally standardized common ICD-9 system.[4] ICD-9 codes are advantageously specific, yet collapsible to general categories. This allows comparisons such as the incidence rates of specific types of tendinitis, such as iliotibial band syndrome or patellar tendinitis, as well as determination of general tendinitis (Table 2).

[SMARTS]

SMARTS can also be used as a surveillance tool, to define baseline morbidity rates, sentinel events, and correlates of risk. Rates of specific diagnoses or groups of diagnoses can be determined in conjunction with local population data on a real-time basis. Fields can be added to permit analyses of risk profiles based on patient information gathered through a number of mechanisms within the clinic setting. In the recruit study, an evaluation of the distribution of injury rates throughout basic training identified two peak periods of risk. This has led to an in-depth description and quantification of training events (e.g., frequency, intensity, and duration) and a modification of the fitness training schedule. SMARTS will be used to evaluate the efficacy of this modified schedule as an injury reduction intervention.

Cost analyses of health care outcomes are becoming increasingly important as a means to set priorities for resources and interventions. Findings from the MCRD recruit study showed that musculoskeletal injuries are common, occurring in approximately 40% of recruits. To better approximate the fiscal and productivity costs of musculoskeletal injuries in recruits, a disposition field (with options such as "return to duty" versus specific rehabilitation protocols) was added to the health-care entry form. Extrapolation of lost training days and fiscal costs

from the recruit study identify musculoskeletal injuries as a major source of morbidity and cost in the Marine Corps recruit training population. Such analysis permits further cost-benefit analyses necessary to evaluate potential interventions. Factoring in the duration of disability permits a more accurate setting of priorities and targeting of particular musculoskeletal injuries. For instance, although tendinitis occurs more commonly than stress fractures, the prolonged rehabilitation period required for stress fractures results in this injury having a far greater impact on productivity.

The administrative and medical record components of ambulatory care clinics are ideally suited for adaptation to an automated information system.[1,3,5,6,7] These systems have been classified into clinical practice or research databases.[2] SMARTS was developed with features of both types of databases. As in clinical practice databases, data entry can be done chronologically in real time by administrative staff, with no data preprocessing and limited data verification. This approach was used mainly in clinic sites where the patient volume was low enough that data entry was an ancillary task for a single individual. Alternatively, SMARTS can be applied as a research database with preprocessed data entry, with data verification done at a later date by research personnel.

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Clinical practice databases with chronological data entry result in a file structure that requires a complicated data analysis effort. Analysis is simplified in SMARTS through the use of relational database techniques. There are also reliability and validity limitations of databases gathered in this manner.[8] One way we attempted to improve accuracy was through the use of a standardized form with a "check-the-box" format. The health care providers found these forms to be useful, quick, and efficient. In addition, SMARTS software includes an extensive module for ICD-9 code selection that adjusts the level of detail and complexity automatically to the knowledge level of the data entry personnel. Overall, the limitations of SMARTS are counterbalanced by the more comprehensive data entry that occurs with real-time data entry by clinic administrative staff.

A major challenge to the implementation of any automated data collection system is successful integration of an information system into the functions of a clinic.[8] The flexibility of SMARTS programming allows site-specific modifications for administrative reports. Computer-generated reports increase efficiency of health care personnel performing these tasks, and they become an inducement to utilize the system.

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Utilization of the system was further encouraged by effective and responsive on-line help and technical support.

In summary, SMARTS is a software system with features of both clinical and research databases. It has been successfully implemented in several ambulatory clinics for the support of epidemiologic research in musculoskeletal injuries and as a resource for health care providers to characterize the profile of illnesses in their outpatient population. Importantly, this system was developed in collaboration with the "end-users", the epidemiologic research team and the clinical staff, which can enhance the quality and applicability of the final software product.[9] The data presented offer an example of how SMARTS can increase the efficiency of data collection for the determination of morbidity rates, correlates of risk, and calculations of the fiscal and functional impact of specific injuries and diseases.

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[SMARTS]

Table 1--Sports Medicine Research Team System (SMARTS) Variables.

Demographic

SSN
First and last name, middle initial
Date of birth
Sex
Race
Branch of military service
Paygrade
Current station
Date reported for duty

Encounter Information

Encounter date
Date data entered
Time checked in and out
Location of treatment facility
Position at facility
Military company/division of patient
Class
Phase of training
Week/day of training

Clinical Variables

ICD-9 code
MMR code (morbidity and mortality report)
Visit number
Injury activity
Patient's complaint
Provider name
Provider comments
Disposition
Duty status
Number of disposition days
Preliminary or final diagnosis
Bilateral designation
Multiple diagnoses

[SMARTS]

Table 2--Incidence Rates of the Most Common Musculoskeletal Injuries among Male Marine Corps Recruit Depot Graduates, January - August 1993 (N = 1,057).

Injury	Incidence Rate (%)
Injury Pathology	
Tendinitis	12.5
Sprain	7.6
Strain	7.4
Stress Fracture	3.7
Specific Diagnoses	
Ankle Sprain	6.2
Blister	6.1
Iliotibial Band Syndrome	5.8
Shin Splint	1.9
Patellofemoral Syndrome	1.1
Patellar Tendinitis	1.1

[SMARTS]

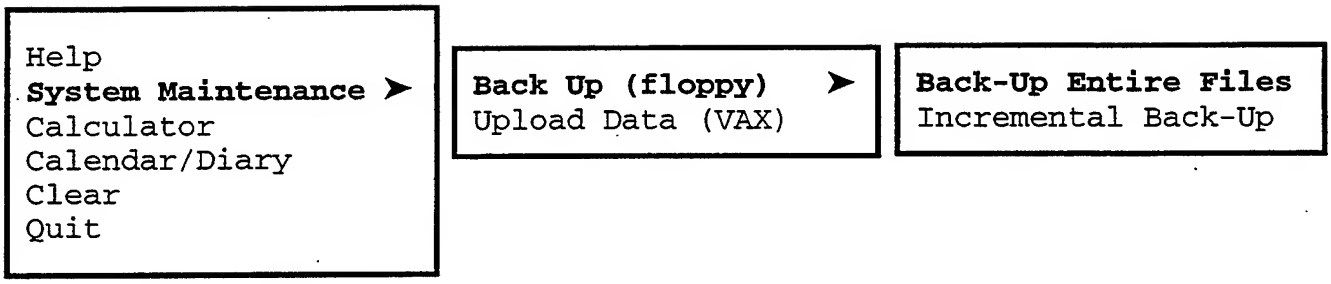

Fig 1. SMARTS System submodules

[SMARTS]

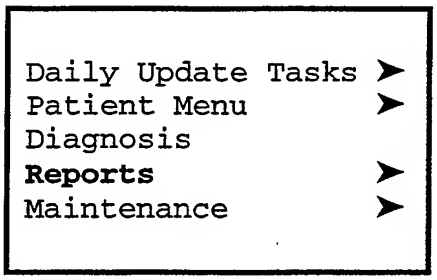

Fig 2. SMART submodules

[SMARTS]

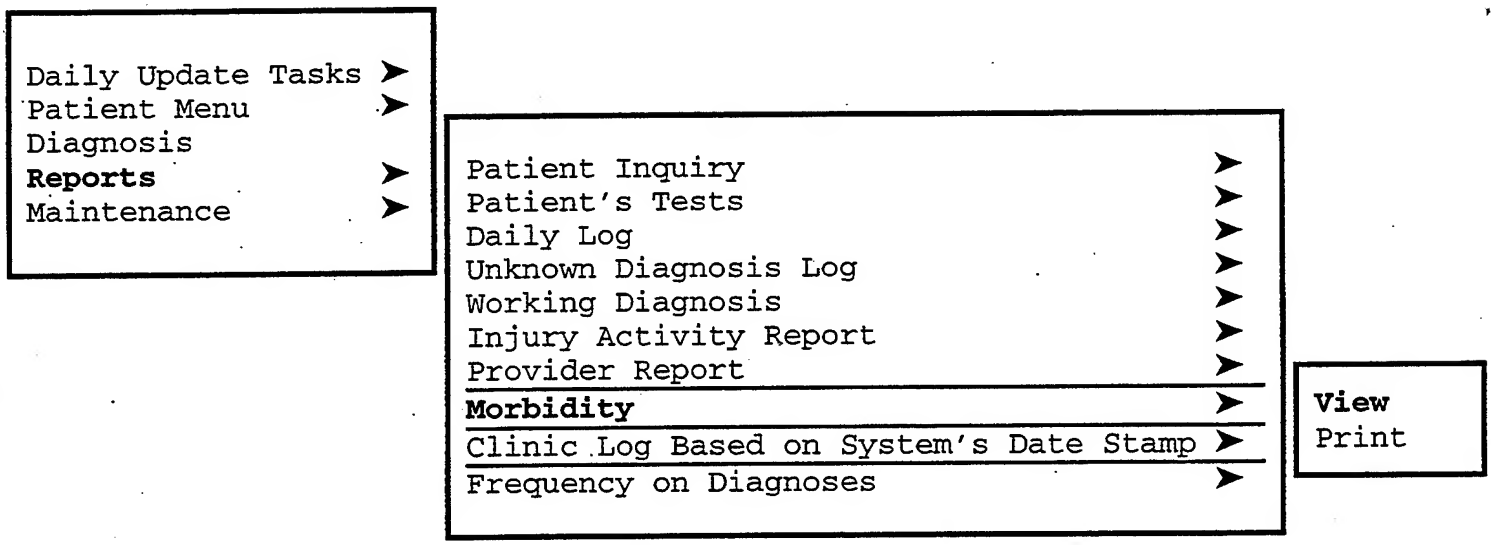

Fig 3. SMARTS Reports submodules

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